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BRIDGE INSPECTION, INVENTORY AND LOAD RATING

New York State Department Of Transportation
OFFICE OF STRUCTURES

LOAD RATING

TECHNICAL ADVISORY

ISSUED BY:	SUBJECT:	DATE:
OFFICE OF STRUCTURES STRUCTURES DESIGN BUREAU	TRUSS GUSSET PLATE ANALYSIS AND LOAD RATING	November 24, 2009
APPROVED BY: G. A. Christian, Deputy Chief Engineer (S)		**SUPERSEDES:** 08-001

09-001

INTRODUCTION

The purpose of this Technical Advisory (TA) is to outline a method for checking the capacity of truss gusset plates when performing Level 1 load rating calculations or checking the capacity of truss gusset plates that have been subject to an increase in loading from their original design. EI 05-034 and the memorandum on "Identifying Truss Bridges that Require Gusset Plate Capacity Checks" referenced in this TA give more information on these aspects. This TA follows procedures recommended by FHWA. This procedure follows the Load Factor (LFD) provisions of the AASHTO "Standard Specification for Highway Bridges, 17th Edition."

Guidelines and a recommended procedure for the analysis and load rating of truss gusset plates using the Load and Resistance Factor Rating (LRFR) method will be issued by a Technical Advisory in the near future.

Guidelines and a recommended procedure for the design and load rating of truss gusset plates on new bridges using the LRFD Specification will be issued by a separate Structures Design Advisory.

BACKGROUND

On August 1, 2007, the I35W bridge over the Mississippi River in Minneapolis, Minnesota collapsed resulting in the loss of 13 lives. The bridge consisted of 14 spans and the failure originated in one of the deck truss spans over the river. On January 15, 2008, the National Transportation Safety Board (NTSB) released a preliminary finding that a serious error in the original sizing of some of the truss gusset plates had been made.

The thickness of the gusset plates at two truss panel points was significantly less than that required by the 1961 "AASHO Standard Specifications for Highway Bridges," which was the applicable design code for the bridge. On January 15, 2008, FHWA issued a Technical Advisory that made the following three recommendations:

1. **New or replacement non-load-path-redundant steel truss bridges.** Bridge owners are strongly encouraged to check the capacity of gusset plates as part of the initial load ratings.

2. **Future recalculations of load capacity on existing non-load-path-redundant steel truss bridges.** Bridge owners are strongly encouraged to check the capacity of gusset plates as part of the load rating calculations conducted to reflect changes in condition or dead load, to make permit or posting decisions, or to account for structural modifications or other alterations that result in significant changes in stress levels.

3. **Previous load ratings for non-load-path-redundant steel truss bridges.** Bridge owners are recommended to review past load rating calculations of bridges which have been subjected to significant changes in stress levels, either temporary or permanent, to ensure that the capacities of gusset plates were adequately considered

This TA addresses recommendations 2 and 3 of the FHWA Technical Advisory by adopting a procedure to check the capacity of existing truss gusset plates. Recommendation 1 will be addressed by a Structures Design Advisory.

TRUSS GUSSET PLATE ANALYSIS AND LOAD RATING

Truss gusset plates and connections of truss members to the gusset plates are ordinarily stronger than the truss members to which they are connected. For this reason, load ratings of trusses have not usually included a check of the gusset plate capacity. However, there are circumstances that make this check necessary. These circumstances include addition of dead load (concrete barriers, increased slab thickness, etc.) to the structure, increased live load (added lanes or deck width; increased traffic count would not be included) and deterioration or loss of section of the gusset plates. The memorandum on "Identifying Truss Bridges That Require Gusset Plate Capacity Checks" has more details on this aspect.

Truss gusset plates are subject to a complex set of axial and shearing forces. Typical design methodology uses general beam theory and decouples the axial and shearing stresses for analysis. This methodology is used in this procedure and can be considered to yield sufficiently accurate results.

All new Level 1 load rating of trusses shall include a check of gusset plate capacity.

LIVE LOAD

Level 1 inventory and operating rating of gusset plates shall be computed.

The analysis and level 1 load rating should be made using HS 20 loading with impact. When the HS 20 Inventory Rating is not met, the H 20 Inventory and Operating Rating should be calculated.

Gusset plate capacities shall be considered in all Level I and Posting considerations in accordance with the latest Engineering Instruction on Load Rating/Posting.

TRUSS MEMBER FORCES

Truss members are designed by placing live loads in positions and combinations that will maximize the force in the individual member under design. The individual truss members at a truss joint under investigation will not all have maximum load simultaneously. Because of this the maximum truss member forces obtained from the design plans or from a load rating analysis will usually not result in static equilibrium at a truss joint. However, the use of the maximum truss member forces is considered sufficiently accurate for this simplified method. Two load cases need to be considered if the diagonals at a truss joint experience stress reversal. Case 1 uses the maximum tensile forces and Case 2 uses the maximum compressive forces.

If the check of an existing gusset plate fails the procedure in the TA using the maximum truss member forces, then the more exact analysis using concurrent forces may be utilized to check its adequacy.

GUSSET PLATE DIMENSIONS

Typically, only the thickness of truss gusset plates is shown on the design plans and it would be necessary to have the shop drawings or field verification to obtain the actual length and width of the plates. However, most design plans should be drawn sufficiently accurate to obtain these dimensions by scaling the drawings.

Bridge Inspection reports should be consulted to determine if there has been significant gusset plate section loss, and if so, this should be accounted for in the analysis.

ANALYSIS CHECKS

If an existing truss has been identified as requiring analysis, all truss joints shall be investigated. However, it may be possible to reduce the number of joints requiring analysis if it can be determined that similarly loaded truss joints have the same gusset plate thickness and configuration.

When analyzing a truss gusset plate, at a minimum the following checks shall be made:

- Shear yielding on the gross and net sections at Sections A-A, B-B and C-C. Horizontal Section A-A is located adjacent to the chord. Vertical Sections B-B and C-C are located on either side of the vertical member or between the diagonals. These sections are illustrated in the Math Cad worksheet.

- Unsupported edge requirement.

- Capacities of the bolted/riveted connection (shear and bearing) of each of the truss members to the gusset plates and to any splice plates.

- Block shear rupture capacity on the gross and net areas subject to shear and tension of the gusset plate at the connections of each of the truss members.

- Tension capacity of the gusset plate on the Whitmore Section (yielding on the effective gross section). The Whitmore Section is defined in the Math Cad worksheet.

- Compressive capacity of the gusset plate on the Whitmore Section. In evaluating the compressive capacity of the gusset plate a choice must be made on the value to use for "k", the effective length factor. In Appendix C of the Standard Specifications for Highway Bridges, the effective length factor "k" for columns can vary from 0.65 to 2.1 depending on the assumed end restraint conditions. In most cases, using a value of k = 1.0 (pinned-pinned or fixed-fixed free to translate) condition should be conservative. If the connection is very heavily restrained by the length of the connection, number of bolts or rivets and the stiffness of the truss member, the value of "k" could be reduced to as low as 0.75. It would be rare to use a "k" of over 1.0 because most trusses have sufficient rigidity to prevent lateral translation of the gusset plate. A possible exception would be the top chord gusset plates on a light half thru truss (pony) where it may be appropriate to use a k = 1.2.

CONTINUATION SHEET

Office Of Structures – Structures Design Bureau	DATE: November 24, 2009	PAGE: 4

SUBJECT: **TRUSS GUSSET PLATE ANALYSIS AND LOAD RATING**

REFERENCES

National Transportation Safety Board Safety Recommendation H-08-1, dated January 15, 2008.

FHWA Technical Advisory T 5140.29, Load Carrying Capacity Consideration of Gusset Plates in Non-Load-Path Redundant Steel Truss Bridges, dated January 15, 2008.

FHWA Turner-Fairbank Highway Research Center Report, "Adequacy of the U10 & L11 Gusset Plate Designs for the Minnesota Bridge No. 9340 CI35W over the Mississippi River" dated January 11, 2006.

FHWA's Publication No. FHWA-IF-09-014, Load Rating Guidance and Examples for Bolted and Riveted Gusset Plates in Truss Bridges, dated February, 2009.

EI 05-034 "Load Rating 1 Posting Guidelines for State-Owned Highway Bridges, " New York State Department of Transportation, Albany, NY, October 2005.

AASHTO "Standard Specifications for Highway Bridges, 17th Edition," Washington, DC, 2002.

AASHTO "The Manual for Bridge Evaluation First Edition/2008".

Memorandum on "Identifying Truss Bridges that Require Gusset Plate Capacity Checks", by George Christian, Office of Structures, New York State Department of Transportation, Albany, NY, February 2008.

AISC's Manual of Steel Construction, Load and Resistance Factor Design, Third Edition, Part 9, dated November 2001.

WORKED EXAMPLE

A Math Cad template with a worked example is available to download at the following link:

https://www.nysdot.gov/divisions/engineering/structures/manuals/technical-advisory

DOCUMENTATION

A copy of the gusset plate analysis shall be placed in the BIN Folder. The documentation should include why the capacity check was done, the percentage of section loss and date measured for splice and gusset plates.

CONTACT

Any questions on this TA should be directed to Wahid Albert of the Structures Design Bureau at (518) 457-4539 or Paul Campisi of the Bridge Safety Assurance Unit at (518) 457-5498 or by e-mail to walbert@dot.state.ny.us or pcampisi@dot.state.ny.us.